Oct. 8, 1946. F. L. DORNBROOK 2,409,024

STEAM TURBINE CONTROL MECHANISM

Filed Nov. 15, 1944 4 Sheets-Sheet 1

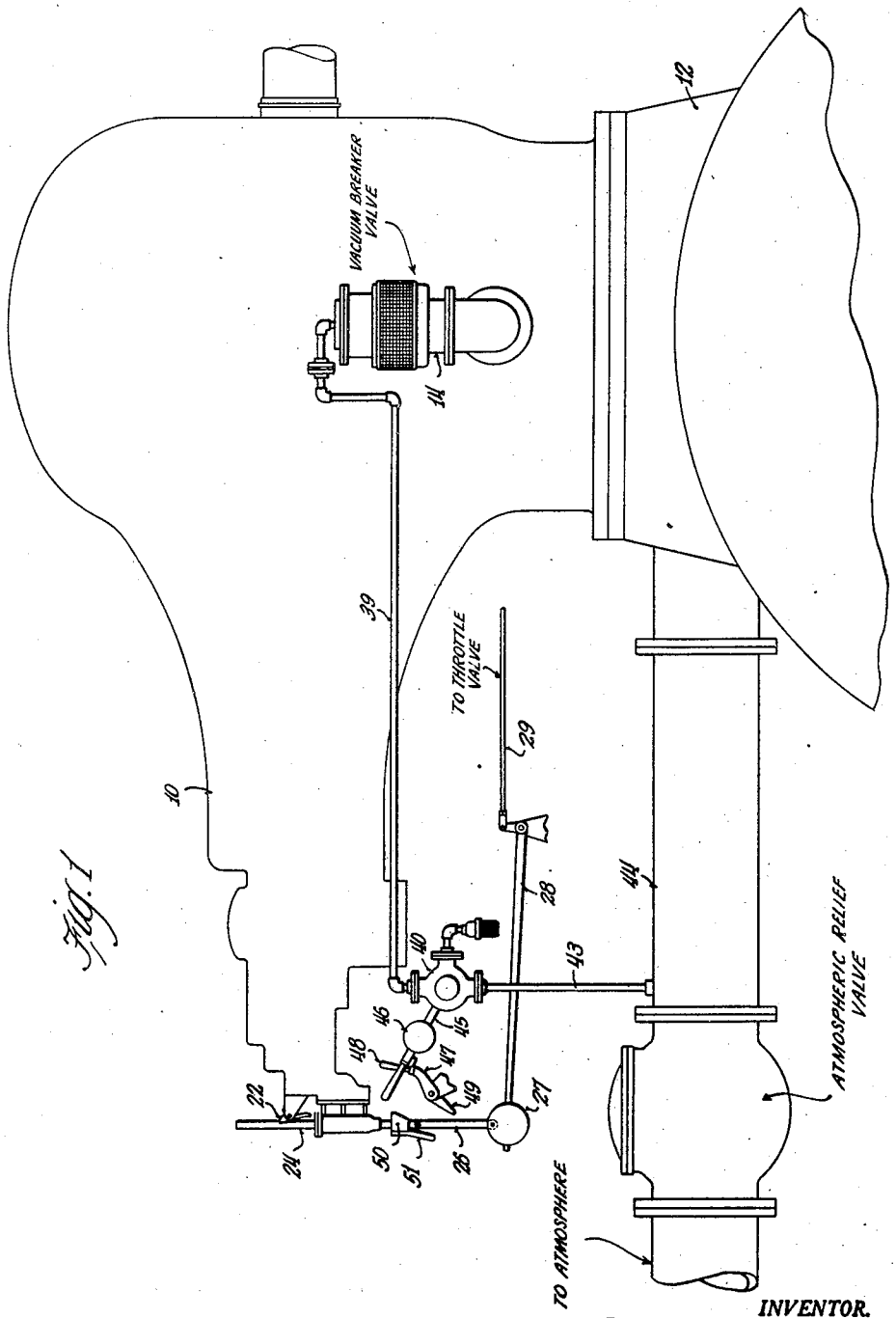

Fig. 1

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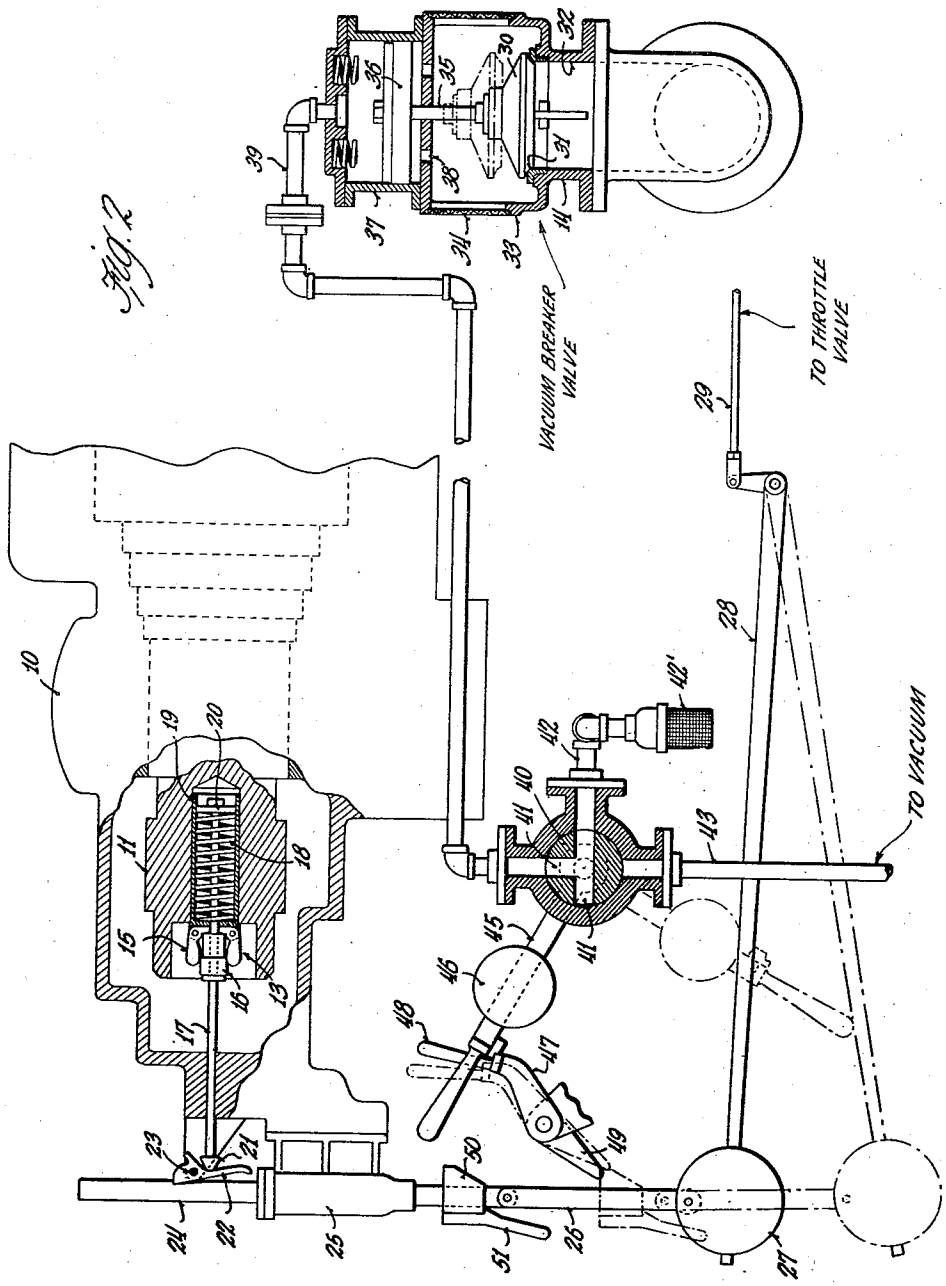

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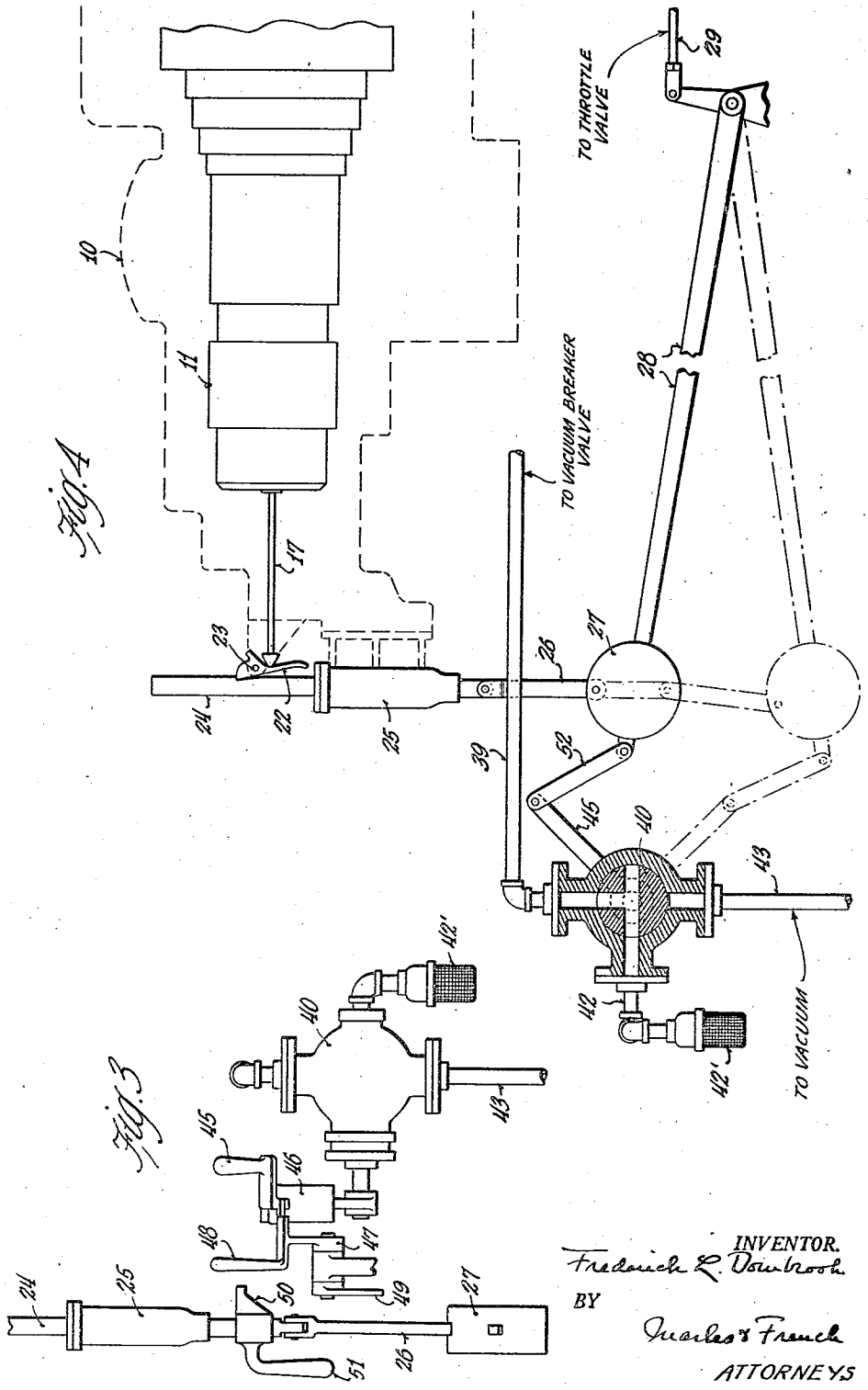

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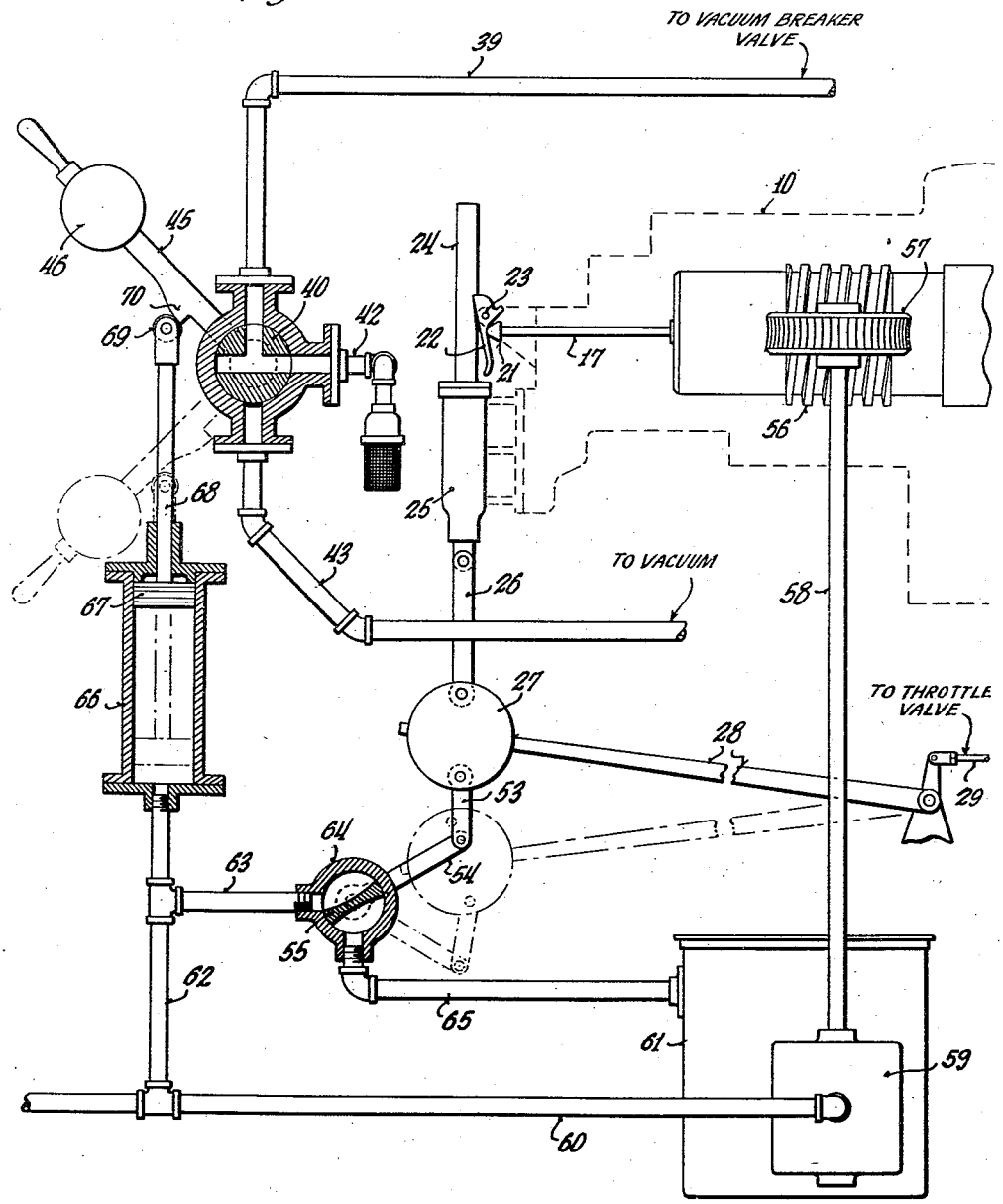
Fig. 5



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STEAM TURBINE CONTROL MECHANISM

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7 Claims. (Cl. 60—95)

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The invention relates to steam turbines and more particularly to control mechanism for the turbine.

Steam turbine condensing units are provided with an emergency overspeed governor which closes automatically all main steam connections to the turbine unit to prevent overspeeding and resultant damage from excessively high centrifugal forces when the load drops suddenly.

The steam exhausted from a turbine is usually condensed in a surface condenser by water circulated through the tubes of the condenser, thus created a vacuum on the blading of the turbine which produces an additional pull on the blading and wheels of the turbine unit and assists in revolving the spindle. It has been found that the vacuum in the condenser can assist in overspeeding the spindle when the load on the turbine drops suddenly even though the emergency overspeed governor has closed all main steam connections to the turbine, and therefore, the immediate and automatic breaking of the vacuum is advisable to supplement the closing of the main steam connections to reduce the speed of the turbine.

It sometimes happens that one or more of the inlet valves or the throttle valve of a turbine leaks admitting uncontrolled steam into the turbine, and if this leakage is enough to cause the turbine to overspeed, the reducing of the speed of the turbine by the automatic breaker valve embodying this invention will prevent damage to the turbine through leaky valves. Furthermore, should the inlet valves or the throttle valve of the turbine fail, so that the emergency overspeed governor is operated, and consequently the vacuum breaker valve is operated, this action will prevent the turbine from overspeeding.

In the past hand operated vacuum breakers have been used but have proven unsatisfactory because of slow action and the human factor involved. At best, the hand operated vacuum breaker answers the purpose only to control the temperatures, and when shutting the turbine down, but in case of an overspeed, even if a man were at the valve, the time required for him to open it would be too slow to produce the braking effect necessary to retard the speed.

The object of the present invention is to utilize a portion of the overspeed energy of the rotating and accelerating turbine spindle to automatically cause the operation of a means to retard the rotation of the spindle. More particularly, according to the present invention, the overspeed energy of the rotating and accelerating turbine spindle

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is used to automatically cause the opening of the vacuum breaker valve and thus retard the rotation of the spindle.

A further object is to utilize a portion of the overspeed energy of the rotating and accelerating turbine spindle to automatically cause the operation of the vacuum breaker valve and admit air into the condenser and thus retard the rotation of the spindle.

A further object of the invention is to provide an arrangement for breaking the condenser vacuum automatically whenever the emergency overspeed governor of the turbine operates by the opening of a vacuum breaker valve which admits air to the condenser and retards the rotation of the spindle preventing overspeeding and reducing the time required to stop or reduce the rotation.

A further object of the invention is to provide a new and improved arrangement for closing the condenser vacuum breaker valve automatically and immediately after the emergency overspeed governor mechanism is re-set by hand to restore normal operation of the turbine.

A further object of the invention is to provide a new and improved arrangement for closing a condenser vacuum breaker valve automatically and immediately after the oil pressure in the turbine's oil governor system is restored to normal.

The invention further consists in the several features hereinafter set forth and more particularly defined by claims at the conclusion hereof.

In the drawings:

Fig. 1 is an elevational view of an automatic condenser vacuum breaker mechanism for a steam turbine embodying the invention;

Fig. 2 is a view similar to Fig. 1 on an enlarged scale with parts of the mechanism shown in section and parts of the turbine being broken away;

Fig. 3 is a side elevational view of parts of the mechanism shown in Fig. 2;

Fig. 4 is a view generally similar to Fig. 2 showing certain modifications;

Fig. 5 is a view similar to Fig. 2 showing another modification.

In all the drawings the numeral 10 designates the steam turbine unit, 11 the turbine rotor, 12 the condenser for the turbine, 13 the emergency overspeed governor, and 14 a vacuum breaker valve mounted and connected to the exhaust hood of the condenser.

The operational features of present day turbine emergency overspeed governor trip action devices are as follows: When the turbine shaft overspeeds, due to loss of load on the turbine or

from any other cause, the revolving weights of the emergency overspeed trip action governor absorb additional energy until they finally overcome the action of the governor spring and through a system of mechanical levers and connecting links operate a trip sleeve (not shown herein) on the steam throttle valve of the turbine. This action releases a spring which closes the throttle valve and cuts off the steam supply instantaneously. Despite this safeguard, the turbine may still overspeed because of expansive force and energy contained in the steam still entrained in the turbine itself, and which may accelerate the spindle quickly especially when this steam is expanded into a high vacuum. Because of this tendency with a turbine using a condenser especially operating at high vacuums to overspeed even though the overspeed governor has operated, it has been found necessary to provide means for reducing the vacuum in the condenser and, as previously noted, such devices have been in the form of a hand controlled vacuum breaker valve which because of the human factor has not proven to be satisfactory. This invention utilizes the force produced by the emergency overspeed governor weights when these weights are subjected to an accelerated rotary motion to automatically operate the vacuum breaker valve to admit atmospheric air into the condenser of the turbine, thereby destroying the vacuum and reducing the energy that is available in the remaining steam to cause overspeeding of the turbine wheels after the emergency governor has operated and also introducing atmospheric air to produce a braking effect on the turbine blading and thus reduces the time required to reduce or stop the rotation of the spindle.

In Figs. 1 to 3 one form of the invention has been shown, and certain modifications of the control mechanism have been shown in Figs. 4 and 5.

Referring to Figs. 1 to 3, the overspeed governor **13** includes the usual centrifugally operable pivoted weights **15** which are mounted to rotate with the turbine spindle or rotor **11** and act on a collar **16** mounted on a plunger or shaft **17**. Resistance to movement of this shaft **17** by the weights is effected by a spring **18** interposed between the end of a supporting sleeve **19** and a collar **20** on the inner end of said shaft **17**. The outer end **21** of the plunger **17** engages a trip hook **22** pivotally mounted at **23** on the turbine housing and normally engaged with a trip gear rod or stem **24** slidably mounted in a guide **25**. The rod **24** has a link **26** pivotally connected to its lower end and carrying a weight **27**. The control for the opening of the main throttle valve of the turbine which acts to close this valve (not shown herein) to shut off all steam connections to the turbine in the event of overspeeding is operatively connected to the trip gear rod **24** by a bell crank lever **28** operatively connected to the weight **27** at one end and at its other end to a link **29** for the throttle valve control mechanism. Thus if the turbine overspeeds, the governor acting on the plunger **17** moves the same outwardly to force the hook or latch **22** out of engagement with trip rod **24**, thus permitting the rod to move downwardly and allowing the weight **27** to move said rod downwardly to turn the lever **28** and operate its connections with the throttle valve to permit said valve to close and thus shut off the supply of steam to the turbine. The governor above described is used in connection with all forms of the invention shown.

The vacuum breaker valve **14** includes a valve member **30** normally seating on a seat **31** at the end of a pipe **32** connecting with the exhaust hood for the condenser **12**. The valve **30** is mounted in a housing **33** having screened atmospheric air inlets **34**. The stem **35** of the valve is slidably guided in the housing **33** and carries a piston **36** slidably mounted in a cylinder **37** mounted on the housing. The cylinder **37** communicates with the atmosphere at its lower end through openings **38** and at its upper end with a pipe **39** that may be connected either to vacuum space of the condenser **12** or to atmosphere. When the upper end of the cylinder **37** is connected to the atmosphere, the pressure of the air acts on the top of the piston **36** which, together with the weight of the piston, valve stem, and valve head closes the valve **30**, thus preventing the flow of air to the condenser, and under these conditions the valve is held tightly to its seat by the vacuum existing in the condenser. When the upper end of the cylinder **37** is connected to the vacuum space of the condenser, the valve **30** is lifted off its seat or opened through the differential pressure action between the vacuum uplift at the top of the piston and the vacuum downpull below the valve seat, the area of the piston being larger than the seat area so that the resultant vacuum pressure on the top of the piston is sufficient to overcome the vacuum downpull and weight of the valve and its parts. Opening of the valve **30** connects the turbine with the atmosphere and breaks the vacuum therein so as to prevent its effecting overspeeding and allows their air to enter the turbine and act as a brake on the turbine blades. The valve **30** when once opened remains open so long as any vacuum exists in the condenser and is used in connection with all forms of the invention shown.

As a means for controlling the operation of the vacuum breaker valve, I show in Figs. 1 to 3 a rotary valve **40** having valve passages **41** therein to connect the pipe **39** either with a pipe **42** open to atmosphere through a screened inlet **42'** or with a pipe **43** connecting said valve with the exhaust conduit **44** leading from the condenser **12** and subject to vacuum conditions in the condenser, this conduit having the usual atmospheric relief valve beyond the pipe **43** and indicated on the drawings. The valve **40** is provided with an operating lever or handle **45** provided with a weight **46** which normally acts to turn the valve to the dotted line position shown in Fig. 2 to establish communication between the pipes **39** and **43** to open the valve **30** but which is held in the position shown in Fig. 2 to connect the pipe **39** with the atmospheric inlet pipe **42** by a pivoted latch lever **47**. The latch lever **47** has a handle **48** adapting it for manual operation and trip finger portion **49** adapted to be struck by a trip member **50** mounted on the trip rod **24**. Thus when the emergency governor **11** releases the trip rod **24** and the weight **27** moves this rod down to the dotted line position shown in Fig. 2 to cause a closing of the throttle valve of the turbine, the trip **50** strikes the latch lever **47** and releases it from the valve handle **45** allowing the weight **46** to turn the valve to a position in which the vacuum breaker valve **30** is opened, thus relieving the vacuum in the condenser and allowing atmospheric air to enter the exhaust side of the turbine and produce a back pressure acting to stop or slow down the turbine. The trip rod **24** has a handle **51**, so that it may be readily re-set manually, and both the valve lever **45** and

the trip lever 47 are provided with handles, as noted above, for manually re-setting and operating the valve trip mechanism when desired.

Fig. 3 shows the position of the handles for the valve trip mechanism and the overspeed governor trip. It will be noted from the above that the operator may use his left hand to engage the handle 51 to re-set the overspeed governor independent of the closing of the vacuum breaker valve and use his right hand for operation of the handle 45 to close the vacuum breaker valve independently, and that he may use both hands for re-setting the overspeed governor and closing the vacuum breaker valve, and that he may manually open the vacuum breaker valve by the manual release of the latch lever 47 from the valve lever 45.

Instead of using a trip mechanism between the control valve and the trip rod I may, as shown in Fig. 4, connect the valve lever 45 of said valve through a link 52 directly with the overspeed governor mechanism with the result that when the overspeed governor operates to release the trip rod 24, the downward movement of this rod by the weight 27 will through the link 52 swing the lever 45 to move the valve 40 from the open-to-atmosphere condition to the open-to-vacuum condition and thus cause an opening of the vacuum breaker valve 30. In this form of the invention there is an instantaneous and automatic opening of the vacuum breaker valve and an instantaneous and automatic closing of this valve when the trip rod 24 is restored, usually manually, to operating position. This form of the invention is particularly desirable when the overspeed governor device has been tripped out accidentally or unintentionally and an immediate and automatic closing of the vacuum breaker valve is required.

Instead of operating the control valve 40 directly by the trip rod 24, the arrangement shown in Fig. 5 may be used in which the trip rod structure is connected by a link 53 with the operating lever 54 of a by-pass valve 55 in oil pressure system for the turbine.

Oil pressure is usually utilized in assisting the main speed regulating governor in controlling the speed of the turbine by opening or closing the steam inlet valves. This oil pressure, during normal operation, is kept at a given pressure by a hydraulic pump geared to the turbine shaft or other means of supplying oil pressure.

As shown in Fig. 5, the turbine shaft has a gear 56 meshing with a gear 57 on a pump drive shaft 58 which operates the hydraulic pump 59 that supplies the hydraulic fluid to the pressure line 60, the oil or fluid being taken from a storage tank 61. The pressure line 60 is connected by pipes 62 and 63 with the housing 64 of the valve 55 which also connects by a pipe 65 with the storage tank 61. When the turbine is operating normally, the valve 55 cuts off communication between the pipes 63 and 65 so that the oil is free to flow under pressure through the pipe 60 to the parts of the turbine which it controls and to the turbine lubricating system. The dropping of the trip gear rod 24 through the action of the overspeed governor will, however, through the main connection 53 turn the valve 55 to a position to establish communication between the pipes 63 and 65, thereby by-passing the high pressure oil from the pipe 60 back to the storage tank 61, thus releasing the pressure in the line 60 and causing the closing of the steam inlet valves mentioned above. At the same time this

release of the oil pressure is used to operate the valve 40 controlling the vacuum breaker valve and is effected, as follows:

The pipe 62 leads to a hydraulic cylinder 66 in which a piston 67 is free to reciprocate and be moved by fluctuations of oil pressure in said cylinder. The rod 68 of said piston extends through the top cover of the cylinder 66 and carries a roller 69 engageable with a part 70 of the valve lever 45. Under normal conditions where the lubricating pump 59 is supplying pressure to the discharge line 60, this oil pressure acting in the cylinder 66 will move and hold the piston 67 in the upper full line position shown in the drawings, and in this position the valve lever 45 will be in the open-to-atmosphere condition so that the vacuum breaker valve, as previously noted, is in its closed position. If under these conditions the trip rod 24 is released by the overspeed governor so as to cause the opening of the by-pass valve 55, the discharge line 60 is then connected to the storage tank 61 and the pressure drops in the cylinder 66 so that the weight of the piston 67 plus the weight of the valve lever 45 will move the valve 40 to an open-to-vacuum condition and thus cause the opening of the vacuum breaker valve 30. Also with this modification in case for any reason the pressure of the oil in the pipe 60 drops below a pressure sufficient to maintain the piston 67 in its upper position, the piston will descend through the action of its weight and that of the lever 45 and thus move the valve 40 to open-to-vacuum condition so as to cause the opening of the vacuum breaker valve 30. As soon as the pressure of the oil in the pipe 60 is restored, it will move the piston 67 to its upper position and consequently move the valve lever 45 to position in which the valve is in an open-to-atmosphere condition to close the breaker valve 30. With this form of the invention it will be noted that there is an instantaneous and automatic opening of the vacuum breaker valve in the event the overspeed governor releases the trip rod 24 and that there is an instantaneous and automatic closing of said valve when the trip rod is restored, usually manually, to operating position.

It will be noted from the above that the opening of the vacuum breaker valve to admit atmospheric air with its braking effect on the turbine produces a back pressure in the exhaust end of the turbine and provides a means for retarding the rotation of the turbine rotor and that this means is instantaneously put into operation through the action of the overspeed emergency governor which by its operation utilizes a portion of the overspeed energy of the rotating and accelerating turbine spindle.

I desire it to be understood that this invention is not to be limited to any particular form or arrangement of parts except in so far as such limitations are included in the clams.

What I claim as my invention is:

1. In a steam turbine having a rotor, a condenser, and a vacuum breaker valve for said condenser, the combination of an overspeed governor for said turbine, fluid pressure operated means to open said breaker valve to reduce the speed of the turbine, a control valve for said fluid pressure operated means, and a trip out mechanism controlled by said overspeed governor for controlling said control valve, and manually operable means for separately restoring said trip out mechanism and said control valve opening

means to a position to restore the normal operation of the turbine.

2. In a steam turbine having a rotor, a condenser, and a vacuum breaker valve for said condenser, the combination of an overspeed governor for said turbine, fluid pressure operated means to open said breaker valve through the vacuum of the condenser to reduce the speed of the turbine and to close said valve on the release of vacuum, a control valve for said valve operating means, and means controlled by said overspeed governor for moving said control valve to breaker valve opening position.

3. In a steam turbine having a rotor, a condenser, and a vacuum breaker valve, the combination of fluid pressure operated means for operating said valve including a cylinder and a piston in said cylinder operated by differential pressure between atmosphere and vacuum in the condenser, a control valve for connecting said cylinder with the condenser to open said breaker valve and with the atmosphere to close said breaker valve, and means controlled by said turbine for moving said control valve to connect said cylinder with said condenser.

4. In a steam turbine having a rotor, a condenser, a vacuum breaker valve, and an hydraulically operated governor system for the turbine, the combination of an overspeed governor for said turbine, means controlled by said governor to open said breaker valve to reduce the speed of the turbine, and means operable by said hydraulically operated governor system to close said vacuum breaker valve.

5. In a steam turbine having a rotor, a condenser, a vacuum breaker valve, and a hydraulic control system for the turbine, the combination

of means to open said breaker valve on a reduction of pressure in said control system, and means to close said valve when the pressure in said control system is restored.

6. In a steam turbine having a rotor, a condenser, a vacuum breaker valve for said condenser and an overspeed governor for said turbine including a trip rod, the combination of fluid pressure operated means for operating said breaker valve including a cylinder and a piston in said cylinder operated by differential pressure between atmosphere and vacuum in said condenser, a control valve for connecting said cylinder with the condenser to open said breaker valve and with the atmosphere to close said breaker valve, and manually resettable means controlled by said governor trip rod for moving said control valve to connect said cylinder with said condenser.

7. In a steam turbine having a rotor, a condenser, a vacuum breaker valve for said condenser and an overspeed governor for said turbine including a trip rod, the combination of fluid pressure operated means for operating said breaker valve including a cylinder and a piston in said cylinder operated by differential pressure between atmosphere and vacuum in said condenser, a control valve for connecting said cylinder with the condenser to open said breaker valve and with the atmosphere to close said breaker valve, and means connecting said control valve with said governor trip rod for moving said control valve to connect said cylinder with said condenser to open said breaker valve and to connect said cylinder to atmosphere to close said breaker valve.

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